SEA
SAILORS ENGINEERING ASSOCIATES, INC.
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ADFREEZE BOND STRESS REDUCTION
Utilizing SlickCoat™ Friction Reduction Epoxy Coating

Frost Heave problems have plagued many projects in Canada and the Northern Regions of the U.S. for years. Especially problematic are lightly loaded structures founded on steel piles extending to relatively shallow depths. In order to evaluate these frost heave problems, Sailors Engineering Associates, Inc. performed laboratory testing to evaluate the effect of various pipe coatings on small diameter steel pipes.

The laboratory testing included determining adfreeze bond stresses under displacements up to 0.170 inches for 2.9 inch outside diameter steel pipes embedded in 6 inch diameter cylindrical sections of frozen soil. The samples were tested by advancing the steel pipes through the soil samples using steel retainer rings with a 3.0 inch hole at the base of the samples to allow the samples to stay intact as the pipes were advanced. The rate of advancement was 0.045 inches per minute. Load versus deflection readings were obtained at intervals of 0.01 inch. The loads at the deflection intervals were determined by a digital load cell.

The pipes coated with SLICKCOAT™ included a pipe with the product brushed on leaving some brush marks (SC-1/SC-2) and one with the product spray applied (NSC-1). Two galvanized pipe sections (G-1/G-2 and NG-1) were used. One bare pipe with factory applied rust protection for storage and shipping (B-1) and one lightly rusted pipe (R-1) were also used.

A graph of the results obtained shows the typical shape of adfreeze stress versus deflection reported by other researchers. The shape includes a peak adfreeze bond stress followed by a much lower residual adfreeze stress after the initial bond has been broken. Except for the rusted pipe section, the residual adfreeze stresses were within a range of 75 to 190 kPa. The peak adfreeze stress values for the brush applied slick coat pipes were 368 and 421 with an average of 395 kPa. The spray applied SLICKCOAT™ pipe had a peak adfreeze stress of 296 kPa. The galvanized sections had peak adfreeze stresses of 678 to 778 with an average of 728 kPa. The bare pipe with the factory applied temporary rust protection had a peak value of 725 kPa while the lightly rusted pipe had a peak value of 1073 kPa.

It is our understanding that the steel piles that have undergone problematic frost heave for lightly loaded structures are not galvanized and have no other protective coating. It is assumed that these piles will behave similarly to the lightly rusted pipe section used in our tests. The peak adfreeze bond stress value of the lightly rusted pipe was about 3.6 times that of the spray applied SLICKCOAT™ pipe.

Conclusions

It is our understanding that design criteria for shallow piles supporting lightly loaded structures which have undergone frost heave include an adfreeze bond stress of 100 kPa for uplift calculations. While this is an accepted value for design and is mentioned in the Canadian Foundation Engineering Manual, it is our opinion, based on the results of our testing and the review of research by others, that this is not an adequate bond stress for design of steel piles for very lightly loaded structures. The peak adfreeze stress values initially experienced by the piles prior to breaking of the initial bond are much higher than 100 kPa. Utilizing the 100 kPa value requires assuming that the initial bond is broken and residual adfreeze stress values are being experienced. This might be a good assumption for structures supported by piles which have medium to high dead loads. It is our opinion, however, that significant movement of the piles could occur during frost heave prior to breaking of the peak adfreeze bond values for lightly loaded piles. TM 5 of the US Department of the Army and the Air Force, Section 4-8.f.3 “Pile Safety Against Frost Heave” (page 4-139) recommends assuming 40 psi (276 kPa) as an average value for the full depth of the seasonal freezing. This value is still well below peak

values experienced in our research and that of other researchers. However, it is probably an adequate design value and does assume that breaking of the peak adfreeze bond stress occurs for a portion of the frost penetration depth resulting in an average of 276 kPa.

Regardless of the adfreeze stress design values used for frost heave calculations, the actual peak value experienced in the field is dependent upon the condition of the surface of the pile. Our research indicates that the use of SlickCoat™ would greatly reduce the value to about 28 percent of that of lightly rusted pile.

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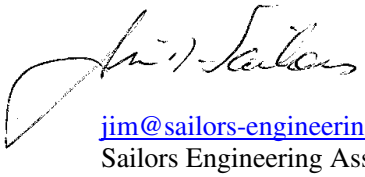

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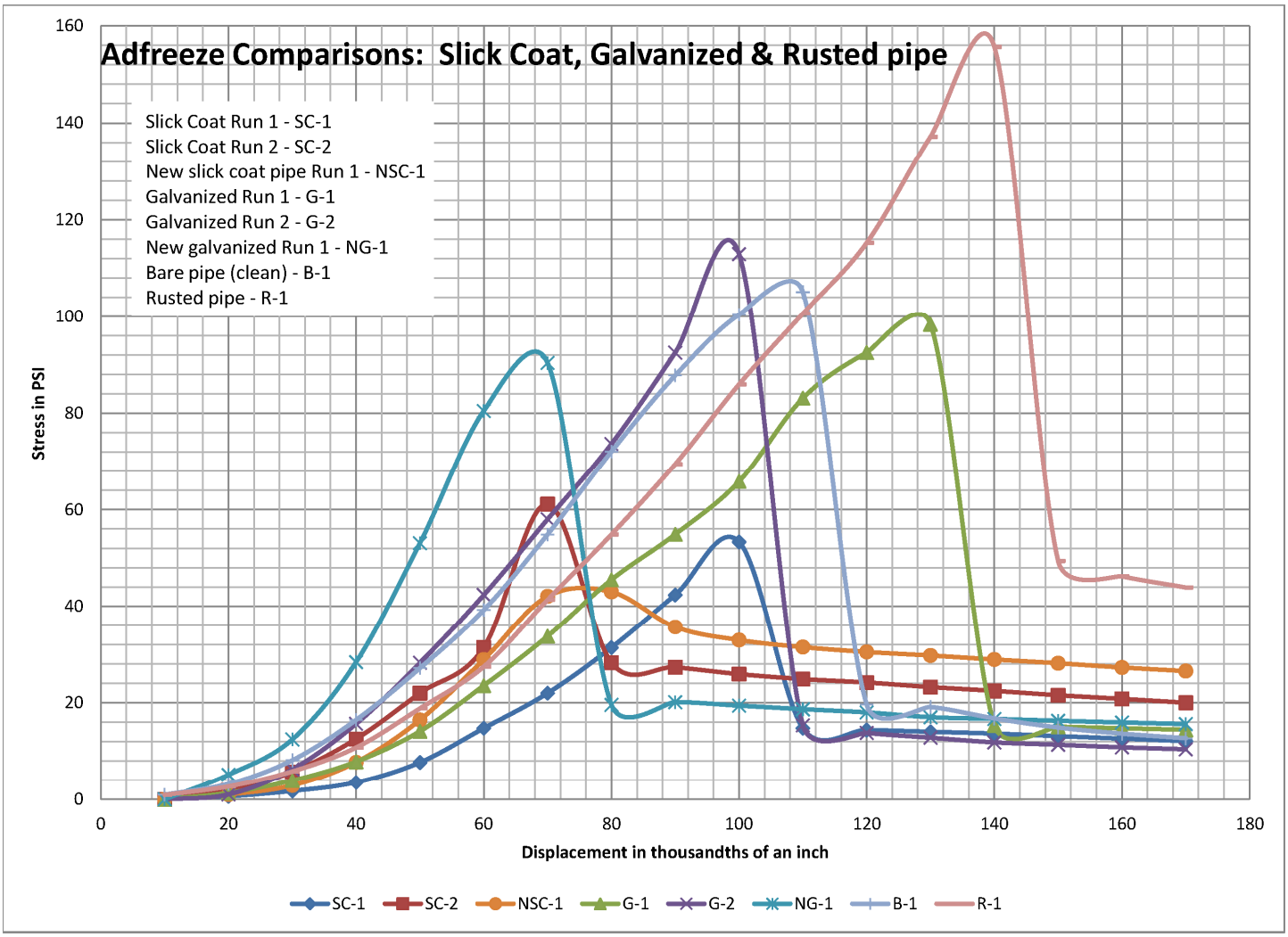
Adfreeze Comparisons: Slick Coat, Galvanized & Rusted pipe
Slick Coat Run 1 - SC-1
Slick Coat Run 2 - SC-2
New slick coat pipe Run 1 - NSC-1
Galvanized Run 1 - G-1
Galvanized Run 2 - G-2
New galvanized Run 1 - NG-1
Bare pipe (clean) - B-1
Rusted pipe - R-1
Stress in PSI
0
20
40
60
80
100
120
140
160
180
Displacement in thousandths of an inch
SC-1
SC-2
NSC-1
G-1
G-2
NG-1
B-1
R-1

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Photo_1

Photo_2